U.S. Army Medical Research and Materiel Command

U.S. Marine Corps Combat Development Command

Re-engineering Medical Care for the 21st Century

30 May 1997

Medical Center

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Hancock County Department of Emergency Medical Services

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Re-Engineering Medical Care for the 21st Century

Introduction

The moral imperative for combat casualty care is constrained by logistics, manpower, and the hostile operational environment. Casualty care is often characterized with long delays to reach definitive care. The initiation of treatment and evacuation begins in a harsh, austere environment, with limited supplies and diagnostic/life-support equipment. Massive tissue trauma, rapid bleeding, uncontrolled hemorrhage and the logistical challenge of providing nonperishable blood and blood products far forward can account for 50% of combat deaths. Head injury and trauma complications are also major contributors to loss of life and extended morbidity. Location of casualties, rapid diagnosis, provision of acute and critical care, and post-treatment monitoring are labor intensive, and must frequently be provided by non-physician medical personnel. Military medical personnel must be provided with the tools and techniques to overcome these conditions. Technology must be compatible with the warfighter's operational mission. We must have available resources to overcome the constraints of unpredictable communications and logistics that are typically noted in military operations.

Today's demonstration will compare and contrast current field medical capabilities with the various research and developmental items that will address future requirements for the care of combat casualties. This demonstration will be conducted in conjunction with civilian emergency medical systems to emphasize the dual use of these advanced technologies and approaches.

Perhaps the best way to illustrate current capabilities is to start by defining a first responder's (combat medic or corpsman) actions in the treatment of casualties. After first locating the casualty, the medic/corpsman arrives with the standard medic's bag (unit 1). It has three compartments in which all the various medical items are stored. The medic/corpsman begins by locating the required items stored among the other medical materials. Once the medical items are extracted, the casualty is assessed, treated and stabilized. The casualty is then tagged with a hand-written field medical card (card 1380) identifying the nature of the injuries and treatments, removed from action, placed on a standard litter, and evacuated by air or ground transport to the next echelon of combat medical care. In the case of multiple casualties, the medic/corpsman must triage all the various injuries and then begin the process of treatment, tagging, and evacuation. Throughout the evacuation process, triage, treatment, and medical information gathering are continued. With limited resources and manpower, the task of the combat medic can quickly become overwhelming when faced with mounting casualties.

Future capabilities will provide soldiers with a warfighter readiness sustainability (WRSA) system so that their physical status can be monitored and their location transmitted to a medic/corpsman in case of injury or a personal status monitoring (PSM). The medic/corpsman will arrive at the site of the injured soldier equipped with a Combat Medic Vest that is composed of ergonomically designed and located compartments so that the medic/corpsman can easily reach and find the desired medical items. The vest will contain the latest advancements in medical devices and materials (i.e., Diagnostic Glove, Fibrin-Polymer Aerosols, Fibrin Bandages, Hypertonic Saline Dextran (HSD) Resuscitative Fluid) to treat the casualty's injuries. The casualty's Medi-Tag will accept data directly from both the WRSA and add the new information to all previously existing medical information on the Medi-Tag. Medical status can

be updated as necessary throughout the evacuation process and transferred to other medical echelons of care. Casualty assessment will be made using a hand-held sensor suite currently referred to as a Diagnostic Glove. Hemorrhage will be controlled with Fibrin Glue Bandages and Fibrin Polymer Aerosols, and small volume resuscitation fluids such as HSD (Hypertonic Saline Dextran) will be administered. The critically injured casualty, initially transported by a litter, will receive intensive care in forward areas with the aid of Mini-STATs and LSTATs (Life Support for Trauma and Transport) in which a computerized, comprehensive physiological system can monitor the casualty's condition, assist in treatment utilizing "smart" technologies, and when integrated with other technologies on LSTATs, perform triage or signal alarms for the medic. The casualty will be transported on the LSTAT to an ASSTC (Advanced Surgical Suite for Trauma Casualties) which rapidly deploys with troops and which, in conjunction with the LSTAT, provides diagnostic and treatment facilities to permit far-forward resuscitative surgery when and where it is needed. The casualty will be transported from the ASSTC on the LSTAT which will maintain or assist stabilization during enroute care, as the casualty is transported by air or land or sea to more definitive surgical or medical treatment centers.

Many of these future technologies will eventually be used in the pre-hospital (emergency scene) setting in the civilian trauma treatment sector. In fact, with dwindling health care dollars, continuity of health care technology between military and civilian applications will help provide common technology basis for common first responder training, certification and sustainment in vital trauma treatment techniques.

The items described in this overview are but a few of the many advanced technologies that can be viewed during the emergency health care demonstration. They illustrate the power and promise of the collaborative efforts of the Department of Defense, national, state and local governments or agencies, and industry and private businesses. These future capabilities demonstrate how re-engineering and application of advanced technologies could transform casualty care to obtain or enhance a "golden hour" for the evacuation of casualties from the battlefield or other scenes of trauma. Such advances will also have significant impact on the treatment of civilian populations in remote, rural areas or congested urban areas and in times of accidental, intentional or natural disasters.

Mobile X-ray Unit

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A hand-held pulsed x-ray unit is under development at the Naval Research Laboratory in Washington, DC.

The unit is being engineered for medical imaging in remote or forward areas.

There are three main benefits of a Mobile X-ray Unit (MXU):

- Totally portable (weight ~16 pounds)
- Intense output with variable photon energy
- No image blurring due to physical motion (x-ray pulse length of ~60 nanoseconds)

The MXU is composed of three subsystems:

(1) The high-voltage drive electronics
(2) The Marx generator
(3) The x-ray output tube

The x-rays are emitted from a 1.5 mm diameter source and have a modified Bremsstrahlung energy spectrum. The peak x-ray photon energy scales with the voltage pulse delivered by the Marx generator; this allows the tube output to be varied between 75 and 150kvp. The ability to vary the photon energy will permit penetration with good contrast of extremities as well as skull and thorax. The x-ray pulse delivers a total integrated dose of ~30 millirems per shot at a distance of 30 centimeters from the exit window of the x-ray tube.

The proposed unit will have the following:

- User selectable menu to control the photon energy
- Automated distance and alignment system
- Powered by rechargeable battery modules
- Remote control option
- Output synchronized with digital x-ray detector system

LifeCell Corporation's Blood Preservation Technology

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Freeze-Dried Red Blood Cells

Convenient storage of transfusable red blood cells (RBCs) is of increasing importance to the military. The Department of Defense (DoD) is interested in the development of a readily available transfusable blood product to reduce the number of combat deaths that result from blood loss. Current methods of red blood cell storage involve cryopreservation at -80°C after treatment with glycerol. This cold storage system requires extensive washing steps prior to transfusion that makes its use in far-forward positions impossible. LifeCell's approach to a practical method of RBC storage, transportation and immediate transfusion is to develop novel methods of freeze-drying in conjunction with buffer formulations which biochemically stabilize the RBC. Our methods will yield a fully functional RBC product capable of satisfying the current requirements for a transfusable blood supply to far-forward positions. Specifically, our procedure will generate a RBC product with the following characteristics.

1. Storage capacity under ambient conditions for prolonged time periods.
2. Ease of transportation.
3. Immediately transfusable blood units due to one-step reconstruction.
4. Effective blood replacement, efficient oxygen delivery, normal RBC circulation.

The successful development of LifeCell's RBC product represents an important contribution to addressing the critical problem of access to transfusable blood supplies in far-forward combat positions. In addition, the versatility of our RBC product in terms of ease of transportation and storage lifetime makes it ideal for stockpiling red blood cells.

Cryopreserved Platelets

The current method of cryopreservation of platelets is logically complex and requires a wash step prior to transfusion yielding a loss of platelets and impaired platelet hemostatic function. Thus, the current platelet storage system is ineffective for combat casualty care. LifeCell has developed a patented system for the long-term cryopreservation of platelets utilizing the biochemical stabilization formulation ThromboSol™ . The platelet preservation system is logistically simple and yields high recovery of platelets cell number with retention of hemostatic function. Furthermore, the platelet preservation system has been designed to allow direct transfusion following thaw. Successful implementation of the ThromboSol™ platelet preservation method will satisfy the requirements for a transfusable platelet supply to far-forward positions. Specifically, the preserved platelet product will have the following characteristics.

1. Logistically simple, one-step platelet processing and freezing.
2. Direct thaw following storage with no post-thaw wash step.
3. Direct transfusion with a high retention of hemostatic function.

Successful completion of the ThromboSol™ platelet cryopreservation system will represent an important contribution to solving the critical problem of access to a transfusable platelet product at far-forward positions. The ability to provide effective hemostasis products in a military situation will save the lives of front line soldiers.

Hypertonic Saline Dextran (HSD)

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Trauma is the leading cause of death among Americans between the ages of 1 and 44. As many as 200,000 lives are lost to trauma each year with an estimated 1 million Americans treated as victims or potential victims of shock trauma. In addition to the emotional impact, the cost to society is tremendous. The annual total is approaching $200 billion; this includes direct costs, such as medical expenses and insurance, and indirect costs, such as lost wages.

On the battlefield, acute hemorrhage accounts for approximately 50% of the fatalities—a statistic relatively unchanged since World War I. Mortality in the military setting could be reduced by as much as 20% through the far-forward administration of effective first aid and resuscitation fluids.

The choice of the best fluid for volume expansion and restoration of blood pressure has been debated for years. The current standard of care involves the administration of crystalloid solutions, such as normal saline and lactated Ringer's. For each liter of blood lost, 2-4 liters of crystalloid must be infused. It is impossible to administer this quantity of fluid in the time available to adequately restore volume and increase blood pressure.

There is a considerable volume of published literature evaluating the usefulness of hyperosmotic/hyperoncotic small volume solutions such as hypertonic saline dextran. The U.S. Army, in collaboration with industry, has been actively involved in the development of this solution for the pre-hospital treatment of hemorrhagic hypotension. The infusion of 250 mL of HSD rapidly expands volume and stabilizes hemodynamic parameters at a volume of 1/10 to 1/12 the volume of crystalloids. This enhances the ability of the combat medic and civilian EMS teams to treat more far-forward casualties. In the event there are mass casualties or intense combat, there may be delayed or extended transport times. HSD "buys" time to transport injured soldiers/civilians to a hospital for life-saving procedures. Clinical studies have shown that HSD improves 24-hour survival and discharge survival.

The availability of HSD will provide the combat medic and civilian Emergency Medical Services (EMS) teams with a small volume resuscitation product permitting them to treat in the field many more casualties than current standards allow. A New Drug Application for HSD has been filed by Medisan Pharmaceuticals Inc., Parsippany, New Jersey.

Computer Aided Medical Assistant (CAMA) System

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The CAMA System was developed by Universal Technical Resource Services, Inc. (UTRS) for the Combat Casualty Care Research Program under a Phase I Small Business Technology Transfer Research (STTR) initiative. The Phase I objective of the CAMA System was to research and develop a Computer Aided Diagnosis and Treatment System designed for field use under battlefield conditions.

Using a commercial off-the-shelf (COTS) mobile, flexible, wearable computer that weigh approximately 1 kg as our hardware platform, UTRS accomplished the following goals:

- Designed and developed a voice-enabled software program that allows the medic to enter and monitor vital sign information as well as navigate through the system via voice recognition.
- Designed and developed a prototype personal computer (PC) Card that can monitor analog vital sign data from non-invasive sensors, digitize and upload the data into the CAMA System.
- Acquired, modified, and integrated COTS non-invasive sensors to the prototype PC Card.
- Researched current state-of-the-art head-mounted display (HMD) technology and integrated an HMD to the wearable computer.
- Incorporated onboard GPS functionality to provide accurate positioning data.

The resulting CAMA System successfully demonstrates the feasibility and functionality of using mobile computing platforms to benefit the field medic.

The Phase II effort will result in a robust and fully functional system with several commercially beneficial products. Under the Phase II program, UTRS will incorporate the following capabilities:

- Completion of all voice-enabled software modules that give the field medic access to an online database of patient statistics as well as hypertexted medical standard operating procedures and protocols.
- Interfaces up to six non-invasive sensors.
- Design and fabrication of a lightweight, color, 640x480 monocular HMD tailored for the field medic.
- Development of an intelligent PC Card that will build on the foundation of the Phase I effort. The Phase II PC Card will incorporate discreet I/O, FIFO processors, and wireless communication functionality.

The resulting CAMA System will actually consist of two subsystems: a remote monitoring subsystem and a fully configured Wearable Computer worn by the medic. The remote monitoring system will consist of a small hand-held processing unit, the smart PC Card, non-

invasive sensors, and monitoring software. The medic's unit consists of the Wearable Computer, voice activated software, a relational database management system, wireless communication, and medical server software. When pre-set thresholds (or combinations of thresholds) are exceeded, the remote unit will transmit warning information to the medic's unit to inform him of the situation. The field medic may also request vital sign information via voice command. Upon command, the medic's unit will transmit the request to the remote unit which in turn will respond with the latest vital sign information.

It is envisioned that the system could be used as a repository for historical patient medical data that could be subsequently used as a benchmark for comparison in the field. These data can be used for a plethora of applications that range from identifying potential allergic reactions to facilitating diagnoses. In addition, electronically recorded field data could be sent ahead to battalion aid stations to prepare doctors for incoming patients. Commercial applications include telemedicine, remote home monitoring, training, and help for the disabled.

The Wearable Computer's specifications are as follows:

Weight:	1 kg
Processor:	Pentium Class, 133 MHz
Memory:	24MB RAM; 510MB Hard Drive
Power:	Battery (Nickel Metal Hydride or Lithium Ion) or AC
Additional:	4 PCMCIA Card Slots; 2 Serial COM Ports; 1 VGA Port; Windows95 Operating System; Full Duplex Audio

Combat Medic Vest

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The Combat Medic Vest System (CMVS) will provide the medic with the capability to carry and access supplies without using his/her hands at all times. The CMVS will be used as a replacement to the medical aidmans current Load Bearing Equipment (LBE) configuration by incorporating elements of the LBE into the medic's fully adjustable CMVS.

Type classification is completed at this time, and a Low Rate Initial Production of 230 is scheduled for late FY97 with limited fielding to follow. The CMVS has also generated interest from the other services as an item that will meet their requirements for medical personnel.

Miniature In-line IV Fluid and Blood Warmer Using Microwave Technology

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Significant progress toward the development of a small, portable IV Fluid and Blood Warmer has been made. This development is based on the commercially successful development of a high flow rate device supported by a U.S. Army contract.

The new device will be small in size, allowing placement close to or in contact with the patient—consistent with the needs of the Life Support for Trauma and Transport (LSTAT) Program. The heating cavity will weigh approximately 5 ounces and require a priming volume of less than 2 ml. The maximum flow rate will be 100 ml/minute. This development has been made possible by the use of passive radiometric sensing to provide non-invasive and accurate measurement of fluid temperature. The radiometric sensor can be located in the transmitter housing rather than the heating cavity. The use of a diplexer allows the separation of the heating frequency of 915 MHz from the receiver, or radiometer, operating at 4 GHz. The diplexer allows the use of a single or common antenna and catheter cable to both transmit (heat) and receive (measure temperature). The diplexer and radiometer eliminate the need for thermocouples and wires, thereby reducing cost and improving performance and safety. The cost of the radiometer is equivalent to the cost of the thermocouples, wires, connectors and amplifiers. The elimination of the thermocouple wires improves system reliability and enhances cable flexibility; in addition, it greatly simplifies the construction of the heating cavity and disposable component.

There are no supply voltages applied to the heating cavity which can be close to the patient—an important safety issue!

The proposed heating cavity will be similar to a small "eyeglass" case into which the disposable unit is inserted and closed. The microwave transducer will be imprinted and imbedded in the metalized plastic heating cavity, which will be fully shielded. The disposable unit must be low cost, and must be easily inserted and removed from the cavity. The patient can then be separated from the system without necessitating removal of the disposable unit from the infusion line.

The advantages of this system over conventional heat exchanger technologies are: (1) the elimination of the water bath, (2) low priming volume, (3) small size and weight, and (4) instantaneous and precise warming of fluid. The commercial applications for this device are significant since the vast majority (possible 80%) of fluid infusions are consistent with the flow rates required for this development.

Electromagnetic Hemorrhage Detection, Location and Imaging (Hemorrhage Detection System: HDS)

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What is it?

The Spectra Research, Inc. Hemorrhage Detection System (HDS) is a far-forward man-portable diagnostic system designed for: (1) Diagnosis and monitoring of closed head injuries; (2) detection and location of intracerebral hemorrhage and hemorrhagic stroke; (3) cranial imaging in near real-time; (4) hemorrhage site location in the abdominal area; and (5) location of pneumothorax.

Its importance?

HDS meets several critical medical needs. Central nervous system (CNS) trauma is the leading cause of death in combat casualties. There is currently no system available to detect and monitor closed head injury in situ. Closed head injuries do not present visible indications of the seriousness of the injury. Standard neurological diagnostic techniques may not be usable for unconscious casualties, hence accurate diagnosis is compromised. Elapsed time between trauma and evacuation is critical. Unnecessary delay may mean death for the casualty. Suspected cases of CNS trauma must be monitored in order to reduce the probability of death. HDS offers this capability. Many diagnostic imaging technologies are available in the hospital environment for obtaining cranial images, but no such imaging capability exists for far-forward areas. Use of CT or MRI is not possible in these rugged, hostile environments. HDS provides a field imaging capability by producing a map of hemorrhage sites in the brain. Monitoring the growth of such blood pools is a capability that is currently non-existent. HDS will provide this capability.

HDS Operation

HDS operates on the principle that different materials respond differently to electromagnetic energy. HDS is capable of detecting differences in geometric properties, such as location and shape, and constitutive properties of materials. HDS operates over specified frequencies and measures the response of materials to electromagnetic energy in those bands. HDS consists of an antenna/applicator, battery pack, transmitter, signal processing, and display unit. Signal-processing algorithms use the sensor data to provide the examiner with information on the location and type of materials contained in the suspect region. HDS output formats are of two types: (1) A linear presentation of blood pool interface location and (2) a cross-sectional image of blood pool boundary. Linear presentation of the data provides one dimensional information for location. This capability is most helpful for immobilized casualty examination. HDS two-dimensional imaging allows the user to determine location of blood pool in the head. This feature requires data over an angular region similar to that used in tomographic imaging.

Summary

HDS is an advanced man-portable, diagnostic tool for detection of intracerebral hemorrhage or hemorrhagic stroke. It provides a portable, far-forward imaging capability to the medic for timely care of casualties.

Forward Deployable Nucleic Acid Analysis System for Medical Diagnosis of Biological Agents and Infectious Diseases

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Currently no capability exists outside of Department of Defense reference laboratories for identifying biological warfare agents in clinical specimens. Likewise, the capability to detect and identify infectious diseases with epidemic potential and historical impact on military operations (i.e., dengue fever, enteric diseases and hemorrhagic fevers), is available only at fully supported clinical laboratories or reference centers. For too many infectious diseases, clinical specimens must be collected in a theater of operations and sent hundreds or thousands of miles away for laboratory confirmation. This labor- and time-intensive process inhibits rapid and effective implementation of medical countermeasures to protect the Force. Preventive Medicine Teams, Pathology Augmentation Teams, Problem Definition and Assessment (PDA) Teams, Echelon II medical laboratories, chemical and biological rapid response teams, and Area Medical Laboratories require rapid (performance in less than 30 minutes), hand-held diagnostic assays with minimal logistical and training burdens. Recently, several advanced technology applications are emerging for point-of-care identification of diseases caused by biological warfare or infectious disease agents.

USAMRIID is leading an effort to adapt technology developed at the Lawrence Livermore National Laboratory that allows for miniaturized nucleic acid analysis for medical diagnosis. A prototype device, which fits into a small briefcase, has already been evaluated in partnership with the Armed Forces Institute of Pathology. Identification of agent-specific nucleic acids could be demonstrated in 25 minutes or less. Follow-on testing is being conducted at USAMRIID Diagnostic Test and Field Evaluation Center (DTFEC) with the 520th Theater Army Medical Laboratory. USAMRIID already has demonstrated assays compatible with the new diagnostic platform for six different biological agents. As envisioned, hand-held instruments will make point-of-care laboratory diagnosis a reality, replacing up to 500 pounds of analytical equipment and supplies currently used. Limited field trials are planned for fiscal year 1998 with broader concept exploration testing being conducted in fiscal year 1999. Hand-held instruments are proposed for transitioning to advanced development by fiscal year 2002.

BW/CW Release Monitoring

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Hazard Assessment

The Oak Ridge Complex, together with the Defense Special Weapons Agency, has developed an automated, knowledge-based forecasting system capable of near real-time prediction of the dispersal of hazardous atmospheric releases of nuclear, biological and chemical weapons/agent material.

This capability will aid in air, sea and land route planning in conducting operations and in attack planning against targets containing weapons of mass destruction. This same capability can support biological and chemical warfare (BW/CW) impact predictions and alerts for personnel within a region of release.

BW/CW Modeling and Monitoring

The Oak Ridge-developed PC-based Hazard Assessment System for Consequence Analysis (HASCAL) provides source information on potential radioactive, biological, or chemical releases as well as downwind doses for assessing health effects. The system can:

- Provide early warning in the field.
- Provide all clear notification.
- Provide impact analysis.
- Operate autonomously.

Modeling and Simulation

Oak Ridge skills in trend modeling and pattern recognition have been applied to geographic, demographic, and intelligence data for scientific and criminal investigations. For example, expertise and facilities support air dispersion prediction, with experience in modeling releases of nuclear and chemical warfare agents to identify areas of expected impact and as a tool for decisions regarding re-entry.

Vulnerability Analysis

Capabilities in modeling and demographic/economic databases can be used to identify locations and agents that might be targets.

Chemical Agent Protection and Response

The Complex can provide expertise in protective clothing for chemical agents; chemical toxicity and biological effects of warfare agents; development of sensors for chemical and biological weapons; and means to verify and destroy chemical warfare agents.

Emergency Preparedness

Oak Ridge has expertise in designing, conducting, and evaluating emergency exercises involving hostage negotiations, released chemical warfare agents, and terrorist dispersion of radioactive material. Specific technical expertise exists in:

- Development of security/emergency management plans and procedures.
- Structure/facility risk and vulnerability analysis.
- Hostage negotiation strategies.
- Performance testing systems.

Radiation Accident Management

Training, consultation and assistance in medical management of patients who have received radiation exposure injuries are available through Department of Energy's (DOE) Radiation Emergency Assistance Center/Training Site (REAC/TS). Specialists are on call 24 hours a day to assist in response to all types of radiation accidents.

MUSTPAC-1
Medical Ultrasound Three-dimensional and Portable with Advanced Communications

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Until now, the mobile, isolated nature of a field hospital has prevented the use of sophisticated but cumbersome diagnostic equipment that is critical to treating life threatening wounds. But now, medical technology experts from the Department of Defense at the Defense Advanced Research Projects Agency (DARPA) and the U.S. Army Medical Research and Materiel Command (USAMRMC), in conjunction with researchers at Pacific Northwest National Laboratory, have developed a portable system that will bring the benefits of sophisticated ultrasound imaging used in major hospitals to the front lines.

The MUSTPAC-1 (Medical Ultrasound Three-dimensional and Portable with Advanced Communications) allows an ultrasound operator to perform three-dimensional scans of an ill or injured soldier, and to send those scans to be interpreted by experts anywhere in the world. Army officials hope this device may someday reduce the number of battlefield deaths. For less severely injured soldiers, the technology promises to provide previously unavailable medical diagnosis and treatment with an improved quality of care at lower cost.

The MUSTPAC-1 is a fully functional prototype system for collecting 3-D ultrasound data and analyzing it using a variety of display and interaction techniques. The MUSTPAC-1 is unique in that it provides an ultrasound telemedicine capability that requires little training and operates even in low-bandwidth store-and-forward file transfer mode.

This portable system can be used by physicians to quickly assess a variety of injuries and illnesses. It is designed to provide on-the-spot visualization of internal bleeding, injuries to solid organs, and penetrating injuries. For more subtle and non-life threatening conditions, the images can be sent electronically to specialists anywhere in the world for further evaluation. Here's how it works: an operator in the field scans a large volume of the patient at one time so that diagnosis during the scan is not required. These data are stored and sent via telecommunication lines or the Internet to a remotely located diagnostician. Using a familiar interface that mimics conventional 2-D ultrasound, the diagnostician can view and manipulate the stored data as if performing a real-time examination on the patient.

In July 1996, a first generation of the portable imagining system was evaluated at the 212th Mobile Army Surgical Hospital (MASH) Camp Bedrock near Tuzla, Bosnia. The physicians of the 212th MASH provided critical input that will make the next generations of systems operate even more efficiently. The end result will be rugged, lightweight, and easily used systems that will be mass-produced and made widely available to physicians in remote areas around the world.

The MUSTPAC-1 system weighs about 85 pounds and fits in a backpack. It operates on standard 120-volt AC power and can be configured to operate on batteries. System components include a Silicon Graphics Indy computer, a modified Hitachi two-dimensional ultrasound system and the Invivo software from Fraunhofer. MUSTPAC-1 is an interim deliverable in a continuing research program funded by DARPA. Planned future development includes engineering improvements, Food and Drug Administration approval for routine use, clinical studies, and commercialization.

In addition to battlefield applications, the MUSTPAC-1 developers believe it will be useful to rural physicians in treating medical emergencies and may be used to provide assistance in hard-to-access places such as mountains, boats, and even outer space.

Life Support for Trauma and Transport (LSTAT) Intensive Care Litter

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Seriously wounded casualties require immediate medical treatment to ensure their survival. At the same time, forward medical capabilities are sparse, with limited personnel and few supplies. The high mobility of future conflicts, and limited ability to project extensive medical care facilities far forward, has resulted in a new doctrine for casualty care. This doctrine emphasizes the need to provide immediate resuscitation and life support far forward, provide limited surgical stabilization near the front, and maintain physiological stabilization of seriously ill patients during extended evacuations (i.e., enroute care).

A suite of medical device technologies was identified and integrated by the U.S. Army Medical Research and Materiel Command into a comprehensive intensive care litter system that meets military requirements for far-forward resuscitation and care during critical evacuation. The Life Support for Trauma and Transport (LSTAT) system is the first platform capable of providing far-forward intensive care to casualties in the field or other remote locations, and offers a significant improvement in capability to diagnose, treat, monitor, transport patients, and perform surgery. It offers an array of monitoring capabilities, and is unique in its integrated systems and capabilities for on-board storage and transmission of real-time patient physiologic data. This will enable integration of medical treatment as the patient passes through the medical chain, improve directing of patient flow in a trauma care network, and enable development of an epidemiologic database to further enhance combat trauma care.

The first generation LSTAT is expected to be fully developed within the next 2 years. It will integrate a set of commercially available, FDA-approved medical device components. Configured to a NATO standard litter, the system includes a defibrillator, positive pressure ventilator, compressed oxygen, suction device, and intravenous fluid and drug infusion pumps. The LSTAT can measure EKG, blood and arterial pressure, respiration rate, respiratory gases, and blood oxygen saturation. It has physiological oxygen delivery capability, and also provides limited blood chemistry analysis. The LSTAT has stand-alone power capability for 1 hour, with connectivity to power systems of all military transport vehicles and airframes for use during evacuation.

Future enhancements will incorporate novel noninvasive physiological sensing technologies and "smart" system control medical assist algorithms for diagnosis and monitoring of treatment efficacy. These "smart" systems will evaluate changes in patient status in real time, predict untoward events, and provide decision-assistance to medical personnel, or alternatively provide computer-directed operation of the platform's mechanical systems (i.e., ventilator, fluid pumps) to correct the situation. This will enhance the efficiency and effectiveness of medical personnel, enabling quality care even in mass-casualty situations with limited numbers of medical personnel per patient. Additional sophistications that will further enhance the resuscitative capacity of the LSTAT are a microwave resuscitative fluid-warming device and a small resuscitative fluid pump capable of infusing up to 160 ml/min. These devices, controlled through the medical assist algorithm, will aid the medic in the regulation of casualty body temperature and fluid

replacement, such that the needs of tissue perfusion are balanced with those necessary to prevent exacerbation of the hemorrhage.

This life support litter system is designed to integrate with the Advanced Surgical Suite for Trauma Casualties (ASSTC). The casualty will travel on the litter with its complement of life support systems (defibrillator, positive pressure ventilator, compressed oxygen, suction device, and intravenous fluid and drug infusion pumps) to the ASSTC where resuscitative surgery ("damage control surgery") will further extend the time window of opportunity for evacuation. When the casualty departs the ASSTC, the LSTAT will continue to provide the necessary life support systems to enhance successful evacuation (enroute care) of the casualty until definitive surgical and medical care can be completed at higher centers of care.

Mini-Life Support for Trauma and Transport (Mini-STAT)

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Battlefield operations are not conducted in the most optimal terrains and conditions. These austere and hostile environments are difficult to navigate, and ground or air evacuation assets may be precluded from entry. There will be times when it will be necessary to extricate casualties from mountainous or marshy terrains, and military operations in urban terrain can pose unique challenges for treatment of battlefield injuries. Under such conditions, a much smaller version of the litter for Life Support for Trauma and Transport (LSTAT) will be required to meet the needs for early life support and rapid transport of casualties from the battlefield. The mini-STAT is designed for such contingencies.

Though similar in concept to the LSTAT, the Mini-STAT will be the size of a briefcase or small suitcase and will be much lighter in weight, which will permit its use in harsh terrains. To meet a reduced weight requirement (17-20 lbs.), it will provide sophisticated, but limited diagnostic and treatment capability. It will provide a ventilation system, suction and bottled oxygen delivery will be limited (10 min.). Physiological monitoring will be limited to pulse oximetry, capnography, blood pressure and ECG, and there will be no defibrillator. Development and implementation of the Mini-STAT are expected within 3 years.

The Mini-STAT will have a monitor/display with an FDA-approved local control system. It will have a battery energy supply to operate up to 1 hour. Data format will be compatible with the LSTAT for easy transmission of patient information to this higher form of life support. The Mini-STAT will carry a small infusion pump and storage for two, 1 liter IV bags.

Future iterations of the Mini-STAT will include the capacity for waveform analysis of blood pressure, feedback for the ventilator system from end tidal CO_2 and pulse oximetry, and addition of medical assist algorithms like those found on the LSTAT. Like the LSTAT, the Mini-STAT will ultimately include a small microwave resuscitative fluid-warming device and a small resuscitative fluid pump capable of infusing up to 160 ml/min. These devices, controlled through the medical assist algorithm, will permit control of casualty body temperature and fluid replacement, so that the needs of tissue perfusion are balanced with those necessary to prevent exacerbation of the hemorrhage.

Advanced Surgical Suite for Trauma Casualties (ASSTC)

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Combat Casualty Care Research Program
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Forward Resuscitative Surgery (FRS) is the initial emergency surgical approach to a combat casualty with the goal of saving life and limb by implementing treatments which net sufficient clinical stability to allow the casualty to be moved to a definitive surgical facility far removed from the area of conflict. FRS focuses on producing a "window" of clinical stability, which can be exploited by the medical evacuation system (enroute care) to reduce the death on the battlefield. It seeks to exploit the most advanced surgical technologies and concepts to achieve this goal and provide these technologies farther forward than ever before. If properly designed, equipped, and employed, FRS should net a reduction in casualties that would otherwise die within 1 to 2 hours of wounding.

An advanced surgical technology and concept that meets many of the essential issues for support of FRS is the ASSTC, which is expected to be in service within the next 2 years. The ASSTC will provide a self-contained, rapidly deployable, small footprint facility capable of providing trauma management, resuscitative surgery, ancillary services, or temporary patient holding. The conceptual design for the ASSTC facility focuses on the mission and addresses most of the requirements in the Operational Requirements Document (ORD) in Mission Area Analysis 45, Health Services, Category I, which is the deficiency calling for an improved Echelon II medical facility. The ASSTC is configured for a forward area combat situation. It will provide limited surgical hemostasis, bowel closure, airway repair and bone splinting necessary to support life and limb for continued evacuation to definitive care.

The adaptability requirement for on-board ship resupply means the ASSTC facility can be readily reconfigured for situations other than combat. As such, the facility can become a postoperative suite, dental unit or decontamination unit. In cases where the Life Support Trauma and Transport (LSTAT) is not available, such as under disaster relief or humanitarian missions, the services supplied by the LSTAT (defibrillator, ventilation, suction, blood analysis, etc.) can be supplied by auxiliary equipment packaged in the ASSTC cabinets, but it will reduce surgical supply storage volume.

The ASSTC is packaged in a small container (5'x5'x10.5') for transport and shipping. All exterior surfaces of the container are used as a floor and roof panel when the unit is expanded into a surgical suite. The container is equipped with eye bolts for handling as an unslung container from helicopters or for use with various parachute and parafoil delivery systems. The container incorporates ground mobilization equipment to permit transport behind a high mobility, multipurpose wheeled vehicle (Humvee) or similar ground transportation.

The facility when fully expanded and deployed consists of a centrally located surgical core unit (SCU) that is configured from the shipping container. The SCU is surrounded on all sides by the triage and recovery areas, which are completely enclosed in a tent-type shelter. Medical supply cabinets are configured along a wall of the shipping container and separate triage from the SCU.

These cabinets are designed for access from either the triage area or SCU. All sides and roof surfaces of the SCU not otherwise covered with equipment or cabinets are enclosed with lightweight composite panels. As such, the surgical core unit becomes a barrier with a slight positive pressure maintained relative to the triage and recovery areas.

The ASSTC tent material will be foam encased in nylon fabric, which will address heat loss and energy consumption issues. Mylar facing will be added to the interior surfaces to enhance cleanability, resist radiative heat loss, and provide an opaque material. The tent frame is designed for nesting within the SCU when shipping. It is composed of a carbon fiber composite material to adequately support the foam tent material.

The tent floor areas will be covered with durable, single-layer vinyl or polyethylene material, which will integrate and seal with the SCU and outer periphery of the tent walls. This will provide protection from the elements and assist maintenance of positive pressure in the triage and recovery areas. There will be a utility access corridor in the floor for potable water, waste water, power and other utilities for the SCU.

A Heating, Ventilation, Air Conditioning (HVAC) power system, a standard unit of military supply, will provide heating and cooling for the ASSTC. It will be combined with a NBC pressurized protection system. This will preferentially provide the SCU with the highest pressure and a slightly lower pressure in the triage and recovery areas.

Critical Care Aeromedical Transport Team (CCATT)

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Mission Statement

The mission of Aeromedical Evacuation (AE) includes air transport of a broad spectrum of patients under medical supervision while delivering optimal care in a dynamic environment. The AE system must be able to support a variety of contingencies from military operations other than war (MOOTW) to major regional conflicts (MRCs) by tailoring AE forces to meet operational requirements.

The CCATT enhances AE of critically ill patients who require continuous stabilization/advanced care during transport to the next level of care. It is a limited, rapidly deployable resource, available in selected situations to augment the AE system when the supported medical treatment facilities stabilization capability is limited.

Team Composition

Critical care physician x 1

AFSCs

44Y3	Adult Critical Care
44Y3A	Pediatric Critical Care
44E3A	ER Specialist
45S3	General Surgeon

Critical Care Nurse x 1

46N3E	Critical Care Nurse
46M3	CRNA

Respiratory Tech x 1

4HO51	Cardiopulmonary Tech

Types of Patients

Previously treated critically ill patients require continuous monitoring and intervention during transport. These patients are still in a state of dynamic physiological flux. Examples include partially treated shock/hemorrhage, respiratory failure, and multisystem trauma. CCATT intervention begins at the AE staging point.

Constraints

- Functions as a component of aeromedical evacuation system.
- Aircraft environment and forward facilities limit diagnostic and therapeutic capabilities and may affect success thereof.
- Limited supply and resupply.
- Limited patient movement items.
- Only go where aeromedical evacuation can support, no stand-alone capability.
- Equipment and equipment maintenance limitation.
- Provides care to only 4 patients.
- Realistic duty day about 12 hours of patient contact.
- Introduction of untreated patients will degrade team capability and deplete resources.

Concept of Operations

A recent shift in national military strategy emphasizes an "evacuate and replace" philosophy, a reduced forward medical footprint, and the movement of stabilized (as opposed to stable) casualties. An extension of this policy requires the aeromedical evacuation of critically ill patients. The CCATT is designed to support this need. This is consistent with doctrine of adaptability of the AE system structure to varied theater requirements.

The AE system needs the capability to move casualties from forward areas shortly after treatment. This drives a need to provide basic to advanced life support at the patient staging point and during AE transportation.

The role of the CCATT is to prepare the critically ill patient for AE and to continue monitoring and intervention in-flight as required. This team does not provide primary stabilization and does not replace forward surgical team capabilities.

CCATT will be DOC statement, UTC tasked from active duty medical treatment facilities operating critical care functions, or from the Air Reserve Component. When employed, this UTC will be a component of the AE system, and personnel should not be tasked against any other UTC.

The CCATT, as an element of the aeromedical evacuation system, should be located at airfields and attached to a mobile aeromedical staging facility (MASF) to support transport of critically ill patients. They will organizationally align under the AE command structure, and will be a supporting element of the MASF or any other AE element they are co-located with, e.g., officer in charge (OIC) at the MASF or aeromedical evacuation control center (AECC), aeromedical evacuation operations team (AEOT) and medical crew director (MCD) on the aircraft.

Personnel require mobility training and must meet all mobility requirements. Aeromedical evacuation training tailored to the specific needs of the team members must be accomplished. Continuing training specific to AE and CCATT should be kept current.

Relationship with AE Crew

In-flight

The CCATT will augment the AE crew. AECMs will continue with standard in-flight duties and assist CCATT as required to enhance AE mission capability.

The CCATT leader is responsible for all clinical decisions regarding critically ill patients while in-flight. This includes on-site clinical management and recommendations for diversion during flight to a facility with a higher level of care.

The CCATT will additionally support the on-board AE crew with other patient care issues as requested by the MCD. The CCATT may be utilized as a resource while enroute if a patient deteriorates clinically.

The MCD will incorporate the capabilities of the CCATT in the cardiac arrest management plan during the pre-mission brief.

The CCATT is subordinate to the MCD for all non-medical issues. The team exists as augmentees to the aeromedical evacuation crew to include assigned flight surgeons. It is expected that all clinical decisions will be established in a collegial and cooperative environment.

Ground Operations Command Relationships

During AE ground operations, the CCATT will fall under the operational control of the MASF OIC, AECC, or AEOT/OIC. Clinical decisions are managed as above.

Clinical Operations

Pre-Flight Ground

The CCATT will be fully integrated into MASF, or other AE ground mission support operations. The CCATT will typically:

- Support patient reception and triage at the MASF, or other AE patient interface point. (Note: The CCATT will not normally employ forward of the airfield from which patients will be loaded onto AE aircraft.)
- Assess the patient's clinical status for flight.
- Perform intervention as required.
- Determine continuing in-flight care requirements.
- Recommend use of CCATT for in-flight crew augmentation.

In-Flight

The CCATT will be capable of in-flight care of four critically ill patients.

Crew Status

The CCATT will be classified as Mission Essential Ground Personnel (MEGP) on mission documentation.

Training

Initial

Didactic instruction on physiology of flight (i.e., altitude effects, noise, vibration, oxygen tension, gas laws), air evacuation system, general aircraft capabilities, austere operations, recent MOOTW operations. This would be a customized course for the CCATT. It would contain applicable highlights of the Aerospace Medicine Primary Course, Aeromedical Contingency Operations Training, and Flight Nursing and Aeromedical Evacuation Technician courses.

- Aeromedical equipment hands-on training.
- Altitude chamber ride.
- Orientation flights: A minimum of one orientation preferably aboard C-130 aircraft.
- Aircraft ground orientation to C-130 aircraft as a minimum.
- Initial mobility training accomplished at home unit.
- CCATT Physicians: Combat Casualty Care Course (C-4) must be ATLS and ACLS trained.
- CCATT technicians: must be ACLS trained.

Sustainment Training

- Annual FTX with a minimum one flight and MASF operations.

Medic-Cam

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The Medic-Cam is a highly integrated, wireless, lightweight system which provides high quality video, audio and data communications between remotely located field personnel and highly trained specialists.

Uses include emergency medical care, tele-maintenance, security and law enforcement, hazardous material handling, ordnance disposal, firefighting, biological and chemical threat response, and remote surveillance.

The system has been integrated into a standard issue Load Bearing Equipment (LBE) vest. A rechargeable 2.6 A/hr. battery provides sufficient continuous power for a 3-hour mission.

The Medic-Cam system consists of a head-mounted, display with a high resolution color camera, microphone, controller, antenna, receiver and battery. The controller is 6 x 51/2 x 1 5/8 inches. It contains the microwave transmitter, DSP video processor for the color camera, a NTSC video processor for the head-mounted display and an audio signal conditioner and driver.

The controller fits into a modified LBE vest pocket. The rechargeable lead acid battery also fits into a vest pocket and provides 3 hours of run time. The receiver is a Motorola VISAR® wired directly to the controller.

Head-Mounted Display

Active matrix LCD
NTSC video, 420H x 230V
Weight: 5 oz.
Power consumption: 350mw

Camera

1/4 CCD, 410, pixel, DSP controller
Resolution: >470(H) x >350(V)
Shutter: 1/60-1/10,000s auto/man.
Weight: 0.1 oz.
Dimensions: dia. 7mm, length: 42mm
Power consumption: 5w

Audio

20-20,000 Hz
Polarized cardiod condenser mic.
Weight: 1.1 oz.
Power consumption: 26mw

R.F.

L band (1.7-1.83 Ghz)
Power output: 250mw
Power consumption: 2.4w
Audio: 2 channel, 10-15,000 Hz
Video: 10Hz - 10MHz
Receiver: 403 MHZ band

TeleDentistry Sites in Europe

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TeleDentistry

Sites in Europe

During the period of 25 January to 15 March 1997, Phase I of a telemedicine network was established for the U.S. Army Dental Corps at numerous sites in Germany, Belgium and Italy. The project, funded by United States Army Medical Research and Materiel Command (USAMRMC) and the European Dental Service Support Area (E-DSSA), consisted of the set-up of 33 Plain Old Telephone Systems (POTS). Each site consisted of a desktop video teleconferencing (VTC) system, the installation of intra-oral cameras and the training of dental personnel at 33 clinics. A set-up and training schedule was sent to the E-DSSA for review and dissemination prior to deployment.

Set-up of the equipment normally took 2-3 hours while training averaged 3 hours. A training manual accompanied the course of instruction. LTC Larry Kudryk (DENCOM), Ft. Gordon, Georgia was the team leader, with Mitra Rocca, Chief Medical Informatician (TRL), Derick Saxton, Systems Engineer (TRL), and 1LT Tom Baker (Center for Total Access), and Alan Fisher, Casualty Care Research Center (CCRC), providing technical support and training expertise.

The Prototyping, Integration and Testing Laboratory (PITLAB) and Deployable Digital Medical Treatment Facility (DDMTF), located at the Telemedicine Research Laboratory at Fort Detrick, provided a testing and integration location where the equipment and systems were assembled, tested and the software programmed for deployment to field dental units.

Larry Speer (TRL), CPT Rivera, and other Logisticians from Landstuhl DENCOM had each complete system packaged and prepositioned at Pirmasens to be inventoried and then delivered to each individual site with the arrival of the team. The equipment was transferred onto the local dental activity command (DENTAC) property books and transported to the individual clinics.

The Teledentistry Workstation consists of a ShareVision PC 3000 and an Intra-oral Camera. The installation of this equipment allowed dentists at remote clinics to use regular phone lines to video consult with specialists on a variety of dental problems. In the past, patients traveled 1 to 4 hours for a dental consultation, now teledentistry consultations can be accomplished in several minutes at the remote clinics with the specialist on line for advice.

Advanced Field-Ready, Fibrin-Based Hemostatic Bandage

American Red Cross
Jerome H. Holland Laboratory
Plasmas Derivatives Laboratory
Rockville, Maryland

Introduction

The majority of combat deaths occur on the battlefield before evacuation to medical treatment facilities. Exsanguination causes about 50% of all deaths on the battlefield. In order to attain significant improvement in the results of combat casualty care, research and development efforts must focus special attention to the management of hemorrhage on the battlefield. In order to reduce mortality due to hemorrhage, soldiers need simple-to-use, lightweight, portable field-ready hemostatic devices.

The American Red Cross is interested in advancing hemorrhage control both in the battlefield and in the operating room. Our goal has been to design and produce a simple, field-ready bandage or wound dressing that will control all forms of hemorrhage. Funded in part by RAD II, of the Combat Casualty Care Program, we have achieved this goal in the form of our Dry Fibrin Sealant Bandage (DFSB). This dressing allows the delivery of a very high quantity of fibrinogen and thrombin to the site of injury, producing a fibrin clot of much higher density than can be achieved naturally. The clot is cross-linked to the wound, and capable of withstanding the high pressures and large flow volumes of severe injuries to both large veins and arteries.

Product Description

The bandage is produced by placing a resorbable backing material into a plastic mold, followed by the addition of the fibrinogen and thrombin at the necessary concentrations. The bandage is then freeze-dried. Upon completion of freeze drying the bandage is packaged into a foil bag.

Testing

In order to evaluate the effectiveness of the bandage, working in collaboration with COL J. Hess of WRAIR and MAJ Holcomb of WBAMH, several in vivo and ex vivo models have been developed. The ability of the bandage to control bleeding from an injury caused by a high velocity, large caliber "mushroom" projectile has been completed. The animals used in this study were adult male goats, which were kept unconscious via deep anesthesia throughout the procedure. The animals were shot with a high velocity .303 round in the outer side of their left rear leg. The resulting injury produced a clean entry wound with an enormous exit wound. The bullet shattered the femur, destroyed all major and minor blood vessels, including the femoral artery, and there was a large amount of muscle loss. When the animals were treated with the standard of care on the battlefield, Army issue gauze field dressings, blood loss was severe, and shock ensued within a few minutes. Animals treated with DFSB showed no significant blood loss at the site of injury, and did not go into shock. To evaluate the ability of the bandage to treat severe abdominal injury, a porcine liver injury model was developed. This model consistently produces a grade V (lethal) liver injury. Compared to control animals and animals receiving the

standard of care (gauze packing), the Dry Fibrin Sealant Bandage significantly reduced blood loss, minimized resuscitation fluid requirements and achieved hemostasis in 2 minutes, and maintained blood pressure. More importantly, the DFSB does not require a re-operation to remove the packing material.

Conclusion

The ARC has developed the most powerful hemostatic agent known. The DFSB has the ability to significantly reduce the number of deaths due to hemorrhage on the battlefield.

Advanced Field-Ready Fibrin-Based Hemostatic Devices

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Introduction

The majority of combat deaths occur on the battlefield before evacuation to medical treatment facilities. Exsanguination causes about 50% of all deaths on the battlefield. In order to improve the results of combat casualty care, research and development efforts must focus special attention on the rapid control of hemorrhage under austere conditions. To reduce mortality due to hemorrhage, soldiers need safe, simple-to-use, lightweight, highly effective systems to stop bleeding. Thrombin and fibrinogen, the body's two most important blood clotting proteins, can provide such a system, allowing a soldier to create an "instant scab" over a large wound on himself or a buddy. Primitive forms of this "fibrin sealant" were developed in World War II and were effective in surgery but were withdrawn because they transmitted hepatitis. Now, modern plasma protein science can make such systems lighter, faster, safer and more effective.

Product Description

Three prototype fibrin sealant hemorrhage control devices have been developed through U.S. Army and the American Red Cross collaboration, a dry fibrin sealant bandage, a liquid fibrin sealant foam, and a very light, dry fibrin sealant powder. The bandage is designed for direct application to an open wound. The foam is designed to fill body cavities and limit internal bleeding and as material to protect open head wounds. The powder is designed for temporary wound closure. High purity human proteins and biodegradable backings are used in the bandage. Simple gas generators, such as bicarbonate and citrate, keep the foam systems light. Finally, milled powders can be applied with great accuracy with simple squeeze bottle sprayers.

Testing

The original dry powder fibrin sealant system (Larson *et al.*, Arch. Surg. 130:420-422) controlled arterial hemorrhage with 1 minute of direct pressure. Such treatment could limit blood loss by 85% and prevent shock. A more advanced prototype bandage controlled hemorrhage from a large ballistic extremity injury in a similar highly effective manner by again reducing hemorrhage by two-thirds and preventing shock [(Holcomb *et al.*, Arch. Surg. (in press)]. Further refinement has produced an even easier to use bandage that is capable of controlling shock, reducing hemorrhage from massive stellate liver laceration by limiting hemorrhage, preventing shock, reducing logistic requirements for surgical care, and allowing primary emergency surgical treatment without the requirement for re-operation to remove surgical packing. A model for testing unilateral intra-chest tamponade with fibrin foam for lung vascular is under development. A dry powder fibrin sealant spray demonstration at the Special Warfare School showed that this method of applying fibrin sealant was effective in controlling

hemorrhage, closing wounds, and maintaining hemorrhage control while the subject was being transported.

Conclusions

Fibrin sealant systems are light and easy to use, they can be made safe and effective for self- and buddy-care and for a variety of EMS and surgical requirements. Testing suggests that these systems will save lives and limbs. The collaboration between the U.S. Army and the American Red Cross to produce better blood systems for the American people continues.

MediTag

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The Department of Defense (DoD) MediTag Project, supported at the Telemedicine Technology Area Directorate in Fort Detrick, Maryland was authorized by the Commanding General, United States Army Medical Research and Materiel Command to design Personal Information Carrier devices for use in military settings. The Project MediTag team is tasked to develop solutions that provide practical, reliable, and secure solutions to this mission. We utilize rapid prototyping methods to achieve cost-effective designs for inclusion in a wide variety of DoD applications.

We have found that for a system to be valuable as a Personal Information Carrier, it must satisfy the following characteristics:

- Durable to withstand the environmental stresses placed on the device, but allowing intentional destruction of the tag under hostile conditions.
- Large storage capacity to accommodate multimedia information.
- Securely store information to prevent unauthorized access, tampering, or data loss.
- Rapid data transfer rate to enable efficient information management.
- Adhere to industry standards and be of simple design to best integrate with existing applications and device.
- Low cost.

The current project MediTag prototype represents what we believe to be a successful implementation of these characteristics. The system is composed of an electronic dogtag-like device where information is stored and a reader/writer device is used to integrate the tags into a computer. The PCMCIA type reader is capable of containing two individual memory tags. Associated system software drivers provide reading and writing as though addressing a system hard drive. The tags allow data capture and delivery of a wide array of data types including x-rays, MRIs, EKGs, sound, movies, or hundreds of pages of text. We are also investigating the insertion of biological and chemical warfare sensors into MediTag devices to allow for exposure monitoring of these agents.

Efficient and secure access to the contents of this record is crucial if we are to take advantage of its many benefits, including decreased incidence of lost records and better tracking of medical interactions. Networking infrastructures that link different computing sites are evolving to enable larger data-carrying capacities. However, there will always be instances in which a network is not available; times when the information present in one location must be transported to another via some physical means. This is the purpose of the Personal Information Carriers, a transportable storage technology.

The current prototype design has the following characteristics:

- Storage capacities of 2 megabytes (uncompressed) data.
- 100% weather proof.
- Supply voltage of 4.75V to 5.25V.
- Breakable design to allow for intentional destruction in the field under hostile conditions.
- Withstand temperature variations from 0 to 70 degrees Celsius.
- Compatible with all types of computer hardware that support the ATA PCMCIA interface standard.
- Storage of any form of digital data.
- Memory cells that do not require batteries.
- Extensible: system will evolve with technology.
- Low cost component architecture.

The key benefits of this system include meeting our current information management requirements in a transportable environment, adapting to a wide range of application needs, and using available base technology, thus ensuring rapid development cycles.

Currently we are pursuing the integration of this technology into several applications, including the DoD Theater Medical Information Program (i.e., TMIP, a constellation of applications designed to improve medical information management on the battlefield), inpatient and outpatient medical management applications, and personnel and finance applications that take advantage of the ability to store demographic and identifying information such as pictures, palm and fingerprints, voice prints, and retinal scan information on the tags.

The Telemedicine Technology Area Directorate (TTAD) is pursing various initiatives within project MediTag. Future developments will include a migration from the current electronic storage technologies into optical storage technologies where light will become the pervasive medium of information storage and transmission (i.e., optronics). With the outlook toward optronic technology, advances in this field are such that a MediTag device could have a storage capacity of a pedabyte (a thousand terabytes or a million gigabytes) and thus be able to transfer that information at a terabyte (a thousand gigabytes per second).

Project MediTag represents the exploration and development of important information technologies that will satisfy military as well as civilian information storage and transportation needs.

V-22 Medevac

William A. Battey
Medium Lift Business Development
Boeing Corporation

Tiltrotors will revolutionize 21st century health services support in a manner not seen since the introduction of medical evacuation helicopters during the Korean War. The Bell-Boeing V-22 Osprey, a twin engine tiltrotor tactical transport being produced for the Marines and Special Operations Forces and the Bell-Boeing 609, a six to nine passenger commercial tiltrotor offer military and civilian aeromedical communities a unique combination of speed, range, and V/STOL capability.

The V-22 tiltrotor is a unique rotorcraft which can takeoff, hover, and land vertically like a conventional helicopter but, once airborne, can convert to a turboprop airplane capable of high-speed, high-altitude, long-range flight. The V-22 can carry 24 combat-loaded troops or 12 litters, or up to 20,000 pounds of internal cargo at twice the speed over ranges four times greater than the helicopters it will replace. It has a large unobstructed 865 cubic foot cabin (big enough to accommodate the Advanced Surgical Suite for Trauma Casualties) with a rear loading ramp that provides easy access for cargo or stretchers. For medical transport missions, the NATO standard litters can be arranged longitudinally in four tiers of three separated by a center aisle. Or the litters can be partially or completely replaced with Life Support for Trauma and Transport (LSTAT) litters. The 6x6x24 foot cabin can be converted quickly from troop lift to cargo or medevac configuration. An integrated night vision compatible digital glass cockpit, precision navigation, advanced sensors, and NBC and icing protection, allow all weather flight operations day and night even in contaminated areas. The V-22 is self-deployable, shipboard compatible, and significantly more maintainable and survivable than today's helicopters. Currently in Engineering and Manufacturing Development and Low Rate Initial Production, first deliveries of V-22s to the Marines will occur in 1999. Initial Operational Capability for the Marines is 2001.

The Bell-Boeing 609 is a 16,000-pound, commercial tiltrotor being designed for executive transportation, natural resource exploration, emergency medical evacuation, governmental support roles and disaster relief. It can carry six to nine passengers or two liters and three attendants in its 258 cubic foot cabin. The 609 will be pressurized and certified for instrument flight into known icing conditions. It will have full Category A performance, a cruise speed of 275 knots, a no-reserve range of 750 nautical miles and a service ceiling of 26,000 feet. The 609 is currently in Engineering Development. First Flight is scheduled in mid-1999 and first customer deliveries are planned for 2001.

The features and performance designed into the V-22 for the Marines and the Special Operations Forces enhance its potential for health services support in the 21st century. Its speed, range, and payload can provide Health Service Support (HSS) units proximity to casualties as close to combat operations as the tactical situation permits. The V-22 can provide the commander with the flexibility to shift HSS units to support combat forces during operations. V-22 performance enhances Health Services Support in a fast moving

"Ship to Objective" maneuver warfare environment. The V-22's V/STOL capability, range, payload, and cabin volume can assure continuity: the optimum, uninterrupted care and treatment of the casualty from the forward area of the combat zone to an area as far rearward as the patient's condition dictates. If the patient's condition requires it, intermediate echelons of care can be over-flown providing definitive treatment sooner, reducing morbidity and mortality and improving recovery times. The V-22's capabilities can help ensure that the coordination of HSS resources in short supply are efficiently employed and effectively used to support the planned operation.

The Bell-Boeing 609 offers the same tiltrotor advantages of speed, range, and V/STOL capability to the civilian aeromedical community. Combined with the other emerging medical technologies displayed here, these unique tiltrotor capabilities offer both military and civilian aeromedical communities the opportunity to cost effectively re-engineer the delivery of pre-hospital trauma management and achieve dramatic reductions in morbidity and mortality.

Tiltrotors will save lives.

Composite Materials for ASSTC

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Composite materials are a combination of two or more materials that act in concert to achieve desired benefits. Typically these materials consist of a matrix material, such as an epoxy, that holds the material together and acts as a load transfer medium, and a reinforcement material, such as a fiber or filler, which imparts high strength or stiffness. Fiber-reinforced composite materials have been around for decades and employed in a variety of applications ranging from fiberglass boats and tub/showers to the advanced composites utilized in aircraft and aerospace.

The Oak Ridge Center for Composite Manufacturing Technology (ORCCMT) was formed to combine the expertise in composite materials throughout the Oak Ridge Reservation and more effectively utilize this expertise to tackle manufacturing issues. The center serves as a key national resource for research, development, prototyping, and industrial deployment of advanced composites manufacturing technology. Areas of active work include materials characterization, complete design and analysis, process and prototype development, and product testing and evaluation. Unique areas of research involve alternate cure methods including Electron-Beam and Microwave Energy Sources for rapid and economical processing.

The Advanced Surgical Suite for Trauma Casualties (ASSTC) project offers a number of unique challenges in terms of providing a compact, sound structure that is durable and relatively easy to transport to and from medical emergencies around the globe. The ASSTC team feels that providing all of these capabilities requires materials more advanced than the structural steels and aluminums typically employed in military structures. Current plans are to make all of the core unit floors, walls, and ceiling out of composite sandwich panels. A sandwich panel utilizes relatively thin face sheets of a strong and/or stiff composite material on both sides of a lightweight spacer material or core. In bending, the spacer material enhances both the stiffness and strength of the composite material in a lever-arm effect with a minimum increase to the weight of the structure. This approach was utilized by the ORCCMT in making foxhole covers for the Army. A composite sandwich foxhole cover weighing approximately 8 pounds manufactured by the ORCCMT replaced a steel foxhole cover that weighed over 30 pounds and was successfully tested. Other sandwich panels similar to those used for food and beverage storage on commercial aircraft will be employed in building the ASSTC storage cabinets.

Beams of other composite materials support the structure and provide a load-sharing path, handling the collapsed core assembly with a fork lift. These structural beams will be employed similar to the manner in which the ORCCMT fabricated a prototype tactical, quiet engine/generator set for the Army. A composite structure replaced the existing metal structure with a structural weight savings of ~50% and overall system weight

savings of ~25%, with equivalent or better noise reduction. The ORCCMT will manufacture molded composite drawers manufactured in a process similar to that developed in a Cooperative Research and Development Agreement to manufacture Army helicopter transmission housings for use in maintenance trainers.

Official Invitation List

1. National

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   b. Mr. Frederico F. Pena
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   c. Mr. D. E. Beck
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   d. Dr. Janie M. Fouke
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   National Science Foundation
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   e. Mrs. Kay Gass (FEMA)

2. State

   a. Congressman Van Hilleary
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   b. Congressman Richard Armey
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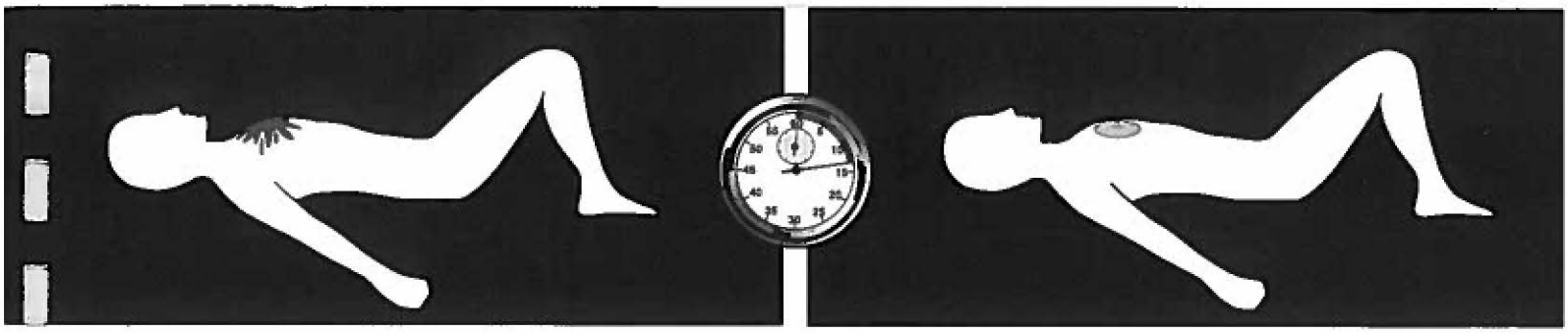

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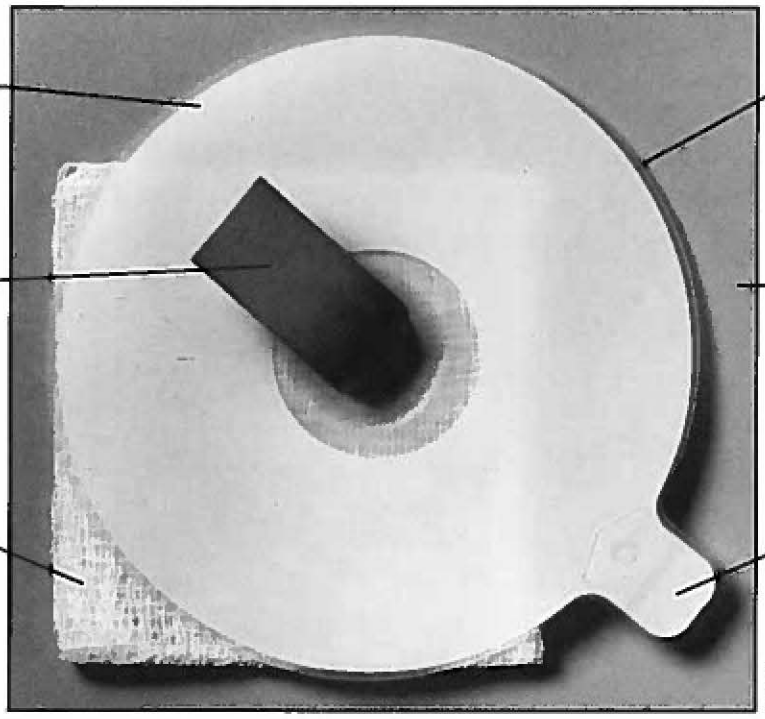

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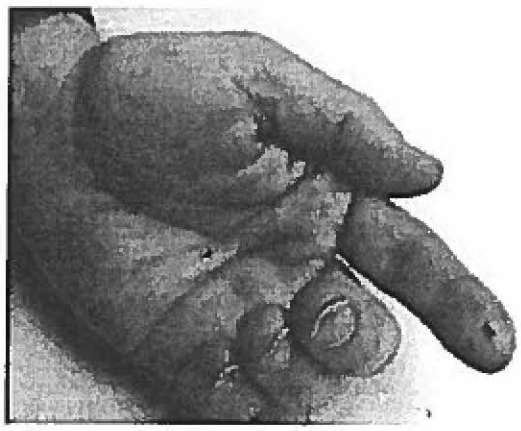

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EMPI Multi-Phase Diagnosis, marketed as **CUPID**, has recently received a 510(k) authorization from the U.S. FDA to market. The use of this **new non-invasive at rest** device may increase cost-effectiveness and further assist the physician in early diagnosis of coronary heart diseases, with an accuracy of 94%.

CUPID is an advanced microprocessor-based device, which incorporates an innovative mathematical transformation approach into its diagnostic algorithm. According to the inventor's thesis, the human heart is a mechanical system, and the engineering notions of system analysis are applied to the ECG algorythms. CUPID transforms the standard EKG signals from the time domain to the frequency domain thus enabling it to read, more precisely, indexes of heart function such as a power spectrum, coherence, cross correlation, amplitude histograms, impulse response, etc. This is done by using biocybernetic principles with new dimensions of mathematical and physical formulae, including Fourier and La Place transformations, and then comparing this data with its 20,000 patient database, all tested with this technology. In clinical trials, CUPID has been consistently 94% accurate ("Double-Blind" testing according to FDA protocol) in detecting coronary artery disease where the standard EKG and Echocardiogram have read normal. Presently, no other existing non-invasive resting technology provides this level of accuracy in cardiovascular diagnosi

WHAT ELSE CAN CUPID DO?

It gives Vascular Surgeons a non-invasive, reliable confirmation of results of re-vascularization and re-perfusion procedures. If the patient is tested on CUPID pre-op, post-op, and periodically afterwards, the frequency analysis can detect the restoration of heart functions. We are presently conducting additional clinical trials for this application at a leading New York area hospital.

CUPID can also differentiate between the following types of heart disease: Coronary artery disease, rheumatic heart disease, pulmonary heart disease, congenital heart disease, myocarditis, myocardiopathy, arrhythmia and ventricular hypertrophy. The differentiation function is more than 90% accurate.

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WHAT ARE THE APPLICATIONS FOR CUPID?

CUPID, can generate additional income for the Family Physicians, General Practitioner, Internists, Vascular Surgeons, and the Cardiologists in the following areas:

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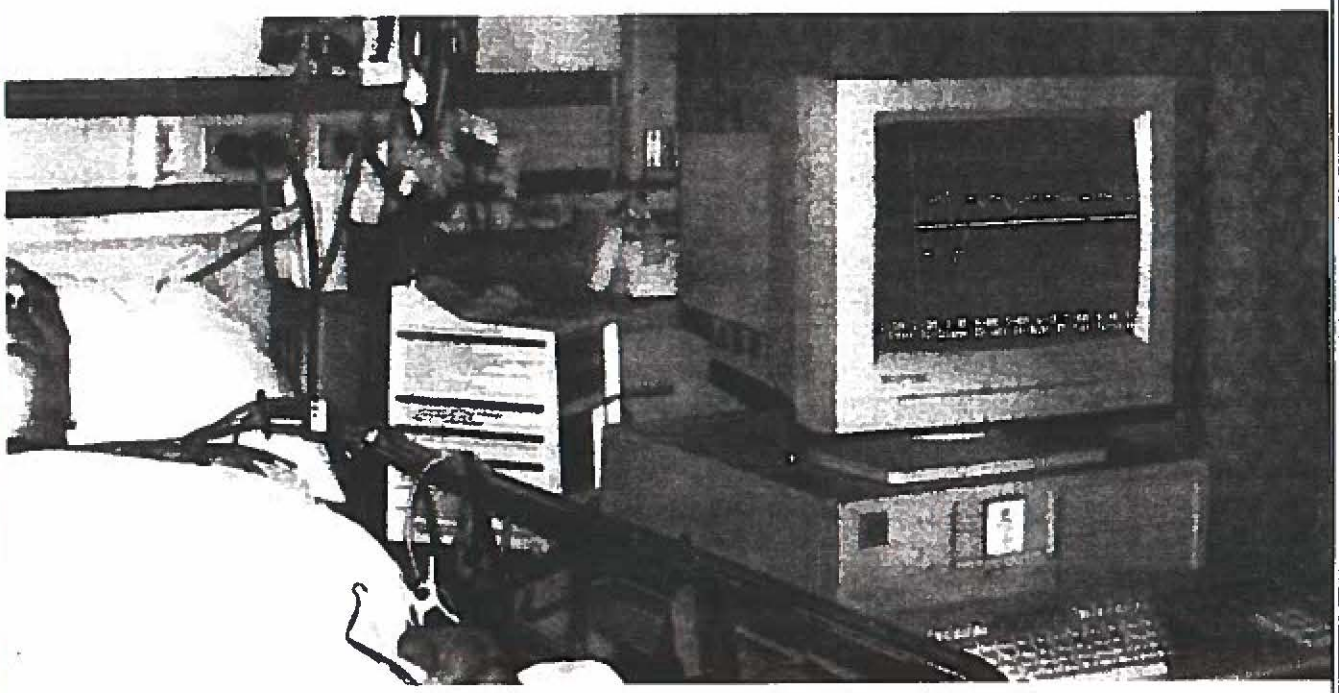
Note: Cardiac Ultra-Phase Information Diagnosis - "CUPID" a/k/a "Advance Level ECG System," a/k/a "EKG Multi-Phase Information Diagnosis System," a/k/a/ "CYBERCORD"."



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Forward Area Resuscitation Pump

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Delivery of intravenous fluid for resuscitation in the field has been gravity-driven for more than 50 years. However, the gravity-driven flow has several significant drawbacks in the field, including: 1) increased risk of exposure under battle conditions due to the need to hold the IV bag in the air, 2) a requirement for a fifth man to carry the IV bag in a 4-man litter carry and 3) poor control of infusion rate and resuscitation.

These problems could be overcome with an active pumping mechanism. However, since there were no commercially available fluid infusion pumps which could deliver flow rates high enough for resuscitation of hemorrhagic shock, we designed a new, highly efficient pumping mechanism which would meet the needs for forward area fluid resuscitation.

The pump we designed with Infusion Dynamics is composed of three basic parts, a reusable control unit, a sterile disposable cartridge and a single-use battery. It uses a sterile disposable pumping cartridge with standard Luer fittings and a built-in air eliminator. The pump can operate as a stand-alone device with the flow rate set using a knob on the side of the pump or it can be controlled by a signal from an external device. This latter feature will allow future implementation of servo-controlled fluid resuscitation based on blood pressure or any other selected resuscitation end-point. The lightweight nature of the pump allows it to be attached to the patient's arm with a Velcro strap. The one-way valve arrangement and non-occlusive pumping action allows fluid to flow freely in the forward direction only. By simply squeezing the IV bag, one can fill the lines or purge the system of air. This free flow feature also provides for fail-safe operation since fluids can be delivered by elevating or pressurizing the IV bag while the pump is off but still connected.

The electrical impedance of the infusion fluid past the air eliminator is continuously monitored and will shut down if a bubble is detected or a fluid below physiologic ionic strength is pumped. The latter prevents accidental infusion of distilled water. The air eliminator prevents the pump from shutting down due to out-gassing at reduced atmospheric pressures, such as that encountered during air evacuation. Alarms are also triggered upon conditions of low battery and IV tube occlusion.

This resuscitation pump infuses crystalloids at rates comparable to an IV bag raised 7 feet above the patient and colloids at rates comparable to a bag raised 15 feet. Compared to inflatable pressure infusers, this pump offers typically lower set-up times, an air elimination filter and greater control over flow rates.

Specifications include:

Size:	2.4 x 3.8 x 1.2 in.	**Weight:**	238 grams
Flow Range:	3-100 ml/min	**Reproducibility:**	± 5%
Battery Life at 100 ml/min	6 hrs		
at 3 ml/min	24 hrs		

Handheld Diagnostic Ultrasound Scanner
ATL Ultrasound, Inc. - Bothell, WA USA

ATL Ultrasound, in collaboration with VLSI Technology Inc., Harris Semiconductor, and the University of Washington, is developing a portable ultrasound scanner targeted for broad clinical application in military and civilian environments. The unit will combine advanced Application Specific Integrated Circuit (ASIC) technology with a high-performance array transducer to provide a high level of clinical utility in a lightweight, low-cost, compact package. Integrated telemedicine capability will allow transmission of acquired images to a remote site for interpretation.

The development program was initiated in February of 1996, and is funded under the Department of Defense dual-use program. The current program will culminate in the production of prototype devices for clinical evaluation in mid 1998. Detailed system design has been completed, and ASIC design is underway.

Recent studies have shown the value of diagnostic ultrasound in the assessment of blunt abdominal trauma, and studies are underway to show efficacy in the evaluation of penetrating wounds, including the detection of shrapnel that is invisible to X-ray imaging. Ultrasound has traditionally not been used in forward-echelon medical units due to the size and weight of available devices, and the difficulty in acquiring and interpreting images. We believe that the handheld device, combined with effective clinical protocols for combat casualty care, will offer significant advantages over current practice. We also believe that the device will find significant application in routine medical applications in both military and civilian health care environments.

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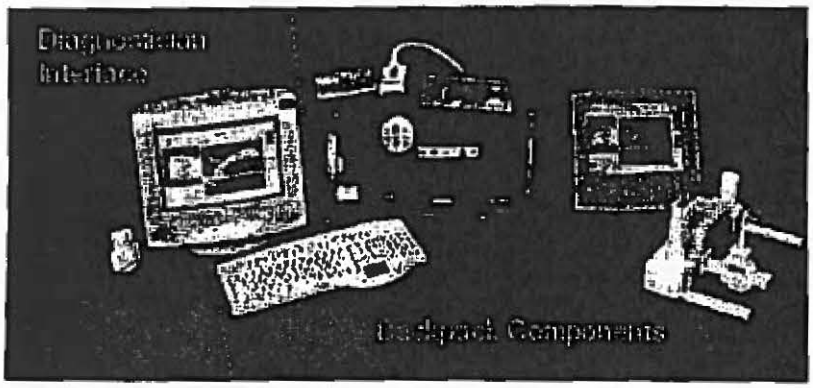
MUSTPAC-1: 3-D Ultrasound Telemedicine

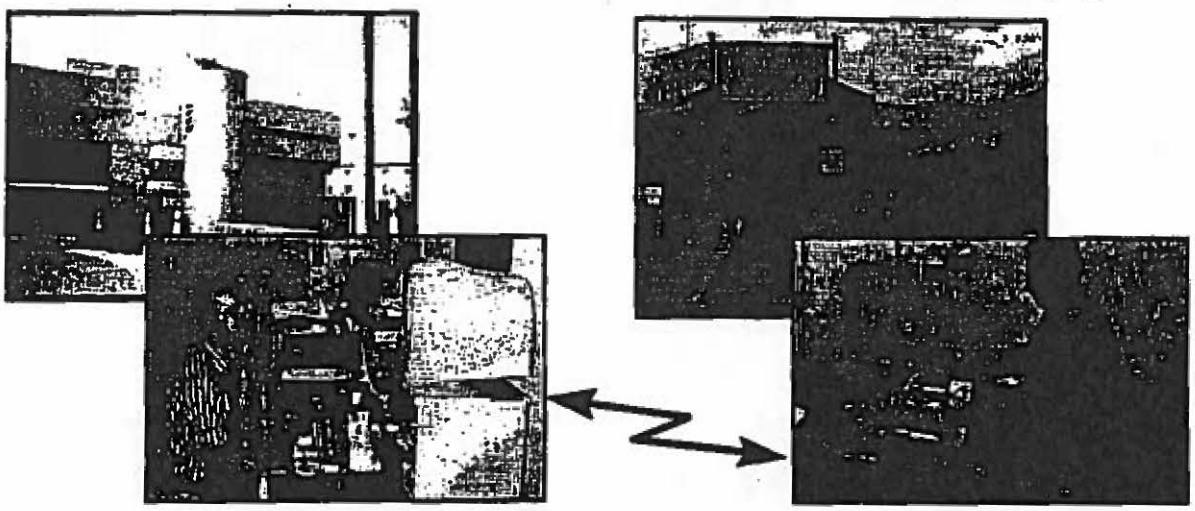
Medical UltraSound, Three-dimensional, Portable, with Advanced Communications

- Innovative design allows effective remote ultrasound diagnosis
- Easy operation -- no diagnostic skills needed to scan
- Natural interface -- rapid acceptance by diagnosticians
- Works over low-bandwidth communication channels -- no need for real-time video link



For more information, see http://www.pnl.gov/3dmed

- Prototypes field tested in Germany and Bosnia, August 1996



Landstuhl, Germany

212th MASH
Tuzla, Bosnia

- Continued development by Battelle, Fraunhofer CRCG, US military, and other collaborators, under DARPA sponsorship.

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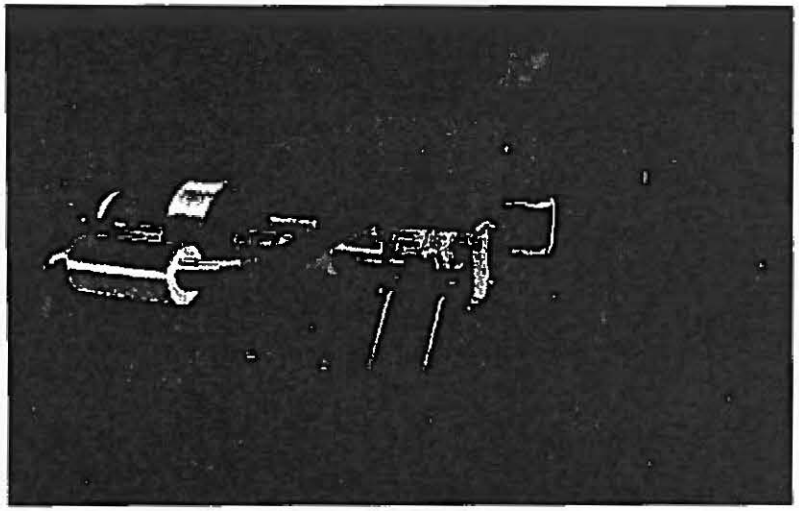
Lightweight Portable Power Supply



Technology

- Low-Noise Composite Housing
- Lightweight Composite Frame
- High Performance Diesel ➡ 0.18 hp/lb
  (Conventional ➡ 0.06 hp/lb)
- Permanent Magnet Axial Gap Generator
- Advanced Inverter Technology

Applications

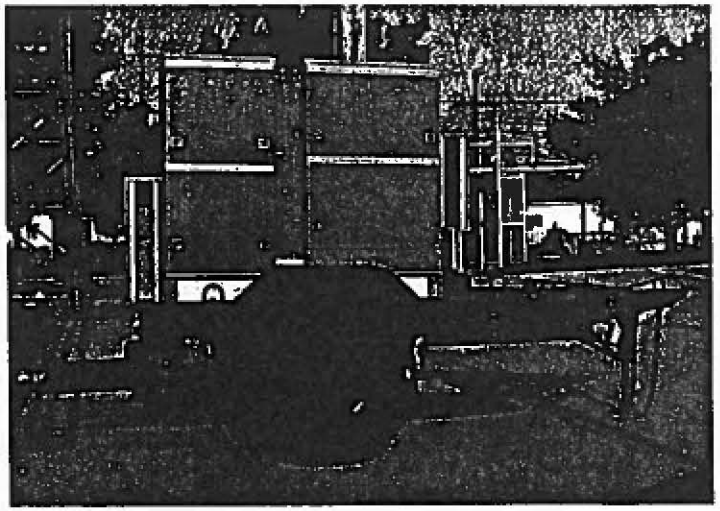
- Aircraft Ground Support
- C^3I Power Supply
- Auxiliary Power for Combat Support
- Battery Charging in the Field
- Field Medical Facility Power

Development Program

- 15 KW System; Less Than 300 lbs
  (Current Commercial Approx. 700 lbs)
- Teaming to Assure Commercial Availability
- Leverage with Existing DOE Program

Point-of-Contact: G. Wayne Morrison
Ph: (423) 574-0574 *or* E-mail: gwm@ornl.gov

Lightweight Power Systems



Tactical Quiet Generator

- Housing: Steel ➡ Composite
- Weight Reduction: 25%
- Low-Noise

Project Types

- Lighten Commercial Products
- Develop Modified Systems for Increased Power Output
- Design and Prototype New Systems
- Power Levels: 400 W ➡ 20KW
- Customized Electrical Output as Needed (Freg., Volt, Current)

Technology

- Lightweight Composite Frame
- Low-Noise Composite Housing
- High Performance Diesel ➡ 0.18 hp/lb (Conventional ➡ 0.06 hp/lb)
- Permanent Magnet Axial Gap Generator
- Advanced Inverter Technology
- Built-In Self-Diagnostics

Point-of-Contact: G. W. Morrison, phone 423 574-2797; eMail: gwm@ornl.gov

ADVANCED TECHNOLOGIES FOR BIOMEDICAL DIAGNOSIS

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Abstract

For the past few years, several advanced techniques and instrumentation have been developed in our laboratory for exposure monitoring and for biomedical diagnosis.

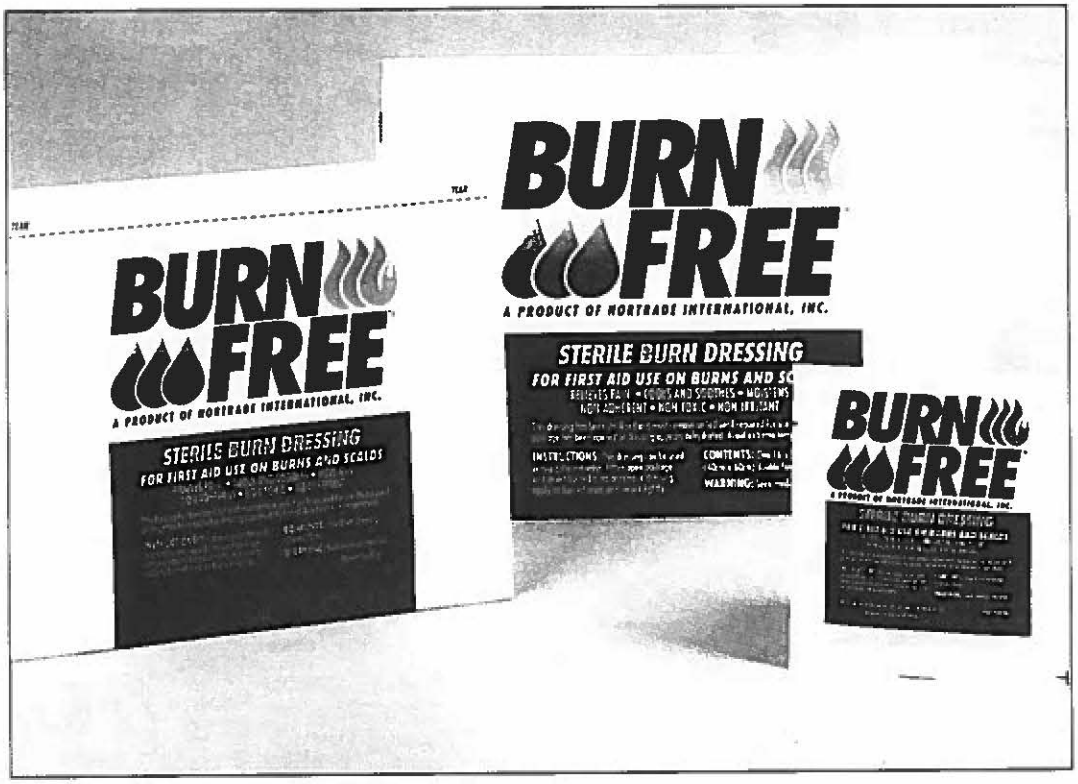
Laser Luminescence. A significant improvement in fluorescence detection of DNA adducts is the synchronous luminescence (SL) technique. Conventional luminescence spectrometry uses either a fixed excitation or fixed emission wavelength. With SL, both excitation and emission wavelength are scanned synchronously, producing a spectrum with a more resolved structure and more readily identified peaks. The combination of tunable laser excitation with synchronous scanning has shown to further improve the sensitivity to zeptomole (10-21 mole). The SL technique has great potentia to improve the detection of low levels of biological warfare (BW) pathogens or simulants.

Surface-enhanced Raman scattering (SERS). The application of Raman spectroscopy for the study of biological species is rapidly expanding because of the specificity of this analytical technique for chemical identification. The SERS effect, whereby an enhancement factor of up to 108 in Raman signals from biological molecules adsorbed on rough metallic surfaces, has generated increasing interest in the Raman technique. For biological samples, conventional Raman spectroscopy has the disadvantage of requiring large samples (usually 10-100 mg of the bulk pure specimens). The increased sensitivity provided by the SERS effect has eliminated this major limitation. Our studies ndicate that this technique has great potential for in vivo medical diagnosis as well as for monitoring chemical exposure using a personnel dosimeter.

Antibody-based fluoroimmunosensors (FISs) have been developed for selective detection of various biological systems. Polyclonal or monoclonal antibodies produced against target antigens are immobilized at the terminus of a fiberoptics probe or contained in a microsensing cavity within the FIS for use both in in vitro and in-vivo fluorescence assays. High sensitivity is provided by laser excitation and optical detection. The FIS device utilizes the back-scattering of light emitted at the remote sensor probe. A single fiber is used to transmit the excitation radiation into the sample and collect the fluorescence emission from the antigen. The laser radiation reaches the sensor probe and excites the target species bound to the antibodies immobilized at the fiberoptics probe. The excellent sensitivity of this device illustrates that it has considerable potential to perform trace analyses of chemical and biological samples in complex matrices.

DNA Biochips. We have recently investigated a new generation of biosensors using DNA probes. Probe recognition is based on the molecular hybridization process, which involves the joining of a strand of nucleic acid with a complementary sequence. Biologically active DNA probes are directly immobilized on optical transducers which allow detection of Raman, SERS, or fluorescent probe labels. DNA biosensors could have useful applications in areas where nucleic acid identification is involved. The DNA probes could be used to diagnose genetic susceptibility and diseases.

BURNFREE® PRESENTS THE NEXT GENERATION OF STERILE DRESSINGS



The gel-soaked burn dressing was a major development in emergency burn care. Now Burnfree is another significant step forward. Burnfree's exclusive open cell foam carrier distributes gel evenly over the wound while holding the gel more efficiently. A technologically advanced gelling agent assures the fact that the gel retains its viscosity throughout a wide temperature range. Unlike older burn dressings still on the market, Burnfree is also approved as a wound dressing that protects cuts, scrapes and abrasions from infection.

Of course, when Burnfree is applied to a burn, the sterile dressing immediately begins to cool and soothe the skin, helping to prevent the burn from progressing.

Burnfree sterile dressings come in three sizes: 4" x 4" (10 x 10cm); 8" x 8" (20 x 20cm); and 16" x 24" (40.5 x .60.6cm).

BURN FREE®

The Next Generation Of
Emergency Burn Care Products Is Here!

Asherman Medical Products, Inc.
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San Antonio, Texas 78217
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E-Mail:amp@MCIONE.com

Richard Asherman